heat more rapidly than it lets it out, the inclosed object—the earth—will become warmer. Assuming that the earth radiates as a black body, the sum of the incident and reflected energy passing through the outer layer is approximately 4/3 of that originally incident, and the radiant energy received by the earth will be about 11 per cent greater than if there were no absorptive layer. The surface of the earth is therefore some 7° C. warmer than it would be without this absorbing layer. But this is a general statement, limited to the action of the isothermal layer alone. In fact, owing to the alternation of day and night, and changes due to the earth's motion in its orbit, the changing angle of incidence of the solar rays, and, above all, the varying distribution of water vapor over the earth, it is a difficult matter to estimate accurately the incoming and outgoing energy.

In the atmosphere itself the heat is not uniformly distributed for, as clouds form, the latent heat of condensation may cause peculiar temperature inversions; and, conversely, as the clouds become invisible, the latent heat of vaporization may also cause an inversion of temperature. Furthermore, there are various convectional gains and losses. The diurnal vertical convection is confined chiefly to the layers below 5,000 meters; but there are certain cyclonic circulations in which the convection extends to higher levels.

If the so-called solar constant were constant, the earth would receive in a year something over one million million million million calories of heat. In popular terms, this is sufficient heat to melt a layer of ice 33 meters (100 feet) thick over the entire earth's surface annually, or to evaporate 1.66×10^{13} kilograms of water. This, then, is what the surface of the earth would receive if there were no atmosphere, and absorbs if there were no reflection.

On the other hand, the surface receives heat from the interior, and a rough estimate of the amount may be obtained by multiplying the temperature gradient in the soil—1° C. for 35 meters—by the average thermal conductivity, which is .006 gram calories per square centimeter per second. According to Abbe and von Herrmann, the amount in a year is 54 calories per square centimeter, or sufficient to melt a layer of ice 7 millimeters thick (0.28 inch). From above and below, then, the atmosphere receives heat.

But the so-called solar constant is not constant, and solar physicists have of late noted changes. Abbot,[1] speaking of variations in his computed values of the solar constant of about 10 per cent states that a change of the intensity of solar radiation of 3½ per cent, due to the decrease in solar distance, occurs from August to October, and this is readily discernible in the work done on Mount Wilson; so that there can be little question that the changes noted there are really solar changes and not of atmospheric or accidental origin.

Kimball states:[2] "There is evidence that the so-called solar constant is a variable quantity. There is stronger evidence that the atmospheric transmissibility undergoes marked changes that are nearly synchronous over considerable portions of at least a hemisphere, and that diminished transmissibility is accompanied by a diminution in temperatures and in temperature amplitudes. Marked diminutions in atmospheric transmissibility occurred in 1884–1886 and 1903–4 that were undoubtedly connected with violent volcanic eruptions. Less marked diminutions occurred in 1891 and 1907 that have not yet been connected with phenomena of this nature."

[1] Annals of the Astrophysical Observatory, p. 235.
[2] Bulletin of Mount Weather Observatory, vol. 3, pt. 2, p. 117, Oct. 19, 1910.

The question then arises: If on the one hand the solar output varies and on the other the transmissibility of the atmosphere also varies according to its dust and vapor content, how are we to differentiate the effects if we make use only of surface temperatures? Accurate measurements of both should be made at widely separated stations. Abbott, from a comparison of temperatures at many points, concludes that certain abnormal temperature departures at continental stations are recognizable as due to change of solar radiation. At insular stations, however, the temperature departures are less marked.

Temperature abnormalities as shown in annual departures may throw some light upon variations in solar output. For this purpose long series of standardized observations are of unusual value, but one must be on guard for variations caused instrumentally.

Meteorologists are now paying special attention to the so-called permanent pressure areas or centers of action. Possibly future study of variations in location and intensity of these centers may lead to the detection of a relation with solar conditions. But at the present time the outlook is not promising. It may be said that there are at least five well-marked ocean highs in the belts of high pressure and two great lows. The intensities, durations, and surface temperatures of the great ocean currents are bound up with the position and strength of these centers.

We return, then, to our open fire and as we watch the coals burn, we realize that the processes through which the solar energy became converted into fuel and all the intermediate steps connected with the heating of the atmosphere are yet largely unknown and imperfectly understood. Assuming that a pound of the imprisoned starshine, or lump of fuel, has approximately 14,500 British thermal units, then the equivalent energy would be about eleven million foot-pounds or a million and more calories. But, as we saw at the beginning, this is practically the amount of solar energy which each square centimeter of the earth would intercept each year, provided the receiving surface were perpendicular to the sunbeam and that there were no atmosphere.

CONVENIENT CONVERSION TABLE FOR FROST WORK.

By A. G. McAdie.

Orchard heaters, evaporators, and frost protectors of various forms have come into such widespread use that a convenient table for the quick conversion of heat units into power units, and vice versa, seems to be much needed.

It may be pointed out that the British thermal unit is the quantity of heat required to raise the temperature of 1 pound of pure water at maximum density, 39.1° F., 1° F. This is the unit most frequently used by engineers in this country and Great Britain, although it is desirable that the old English units and the Fahrenheit scale be used as little as possible. A British thermal unit is equal to 0.252 calorie and also equal to 777.5 foot-pounds. One therm will raise the temperature of 1 gram of water 1° C.; 1,000 therms equal 1 calorie, equal to 3.968 British thermal units.

In problems connected with the heat of water, it should be remembered that the total heat is the latent heat plus the sensible heat. The total heat required to evaporate water at a given temperature is 1,059.7 + 0.428 T, where T is given temperature. This holds for temperatures between 32° F. and 212° F.

In changing to steam at 212° F. a pound of water at 212° F. absorbs 970.4 British thermal units and the total heat is therefore 1,150.4 British thermal units. This is starting from a temperature of 32° F. A pound of ice at 32° requires 142.4 British thermal units to change into water at 32° F.

The latent heat of aqueous vapor may be found from the following formula:

$$L_d = 1,091.7 - 0.572\ t_d$$

Where L_d = latent heat

t_d = temperature of water.

For convenience in frost work the following may be used:

1 kilowatt hour=3,412.66 B. t. u.
1 H. P.=746.3 watts.
1 H. P. hour=2,544.6 B. t. u.
1 B. t. u.=777.5 foot-pounds.
1 B. t. u.=0.252 calories.
1 calorie=1,000 therms.
1 calorie=3.968 B. t. u.
1 calorie per kilogram=1.8 B. t. u. per pound.
1 pound of air at 32° F. occupies about 12.4 cubic feet.
1 pound of water at 212° F. occupies 0.0161 cubic feet.
1 pound of steam at 212° F.occupies 26.14 cubic feet.
1 pound of water at 212° F. contains 181.8 B. t. u.
1 pound of steam at 212° F. contains 1,150.4 B. t. u.
1 pound of ice requires 143.8 B. t. u. to change to water.
1 cubic foot of water at 212° F. weighs 59.84 pounds.
1 cubic foot of water at 62° F. weighs 62.2786 pounds.
1 cubic foot of steam at 212° F. weighs 0.03826 pound.
1 cubic foot of dry air at 32° F. weighs 568 grains.
1 cubic meter of dry air at 0° C. weighs 1,293.05 grams.
Specific heat of water, 1.000.
Specific heat of ice, 0.489.
Specific heat of water vapor, 0.453 at atmospheric temperatures.
Specific heat of air, 0.241.

Values given above are laboratory values, obtained by using distilled water. Ordinary drinking water is heavier than distilled water, because of matter in solution. Salt water is also heavier. It may also be remarked that the temperature of the freezing point in ordinary use, i. e., 32° F., or 0° C., may not hold for the freezing of water in plant life. W. N. Shaw instances one plant where the freezing point is apparently 21° F. In other words, the change of water from the liquid to the solid state under natural conditions is somewhat different from the change as studied in a laboratory.

NOTE.—Some of the values given above differ slightly from those found in textbooks, but it is believed they are the most recent.